DOCUMENT RESUME

ED 092 359 SE 017 721

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TITLE The Science Education Doctorate: Competencies and Roles.
PUB DATE 17 Apr 74
NOTE 24p.; Paper presented at the Annual Meeting of the National Association for Research in Science Teaching (47th, Chicago, Illinois, April 1974)

EDRS PRICE MF-$0.75 HC-$1.50 PLUS POSTAGE
DESCRIPTORS Curriculum; *Doctoral Programs; *Graduate Study; Program Development; *Science Education

ABSTRACT

This document, although substantially based on the results of empirical inquiry, is basically a position statement dealing with doctoral programs in science education as well as other areas of curriculum and instruction. The author contends that doctoral programs in science education should provide for in-depth training of students in one of three specialization areas in addition to a general science education preparation. These three areas are: (1) research and evaluation, (2) development, and (3) instructional leadership (teacher education and implementation of curricular change). (PEB)

ED 092359

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THE SCIENCE EDUCATION DOCTORATE:

COMPETENCIES AND ROLES

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Presented at the annual convention of the National Association for Research in Science Teaching in Chicago, Illinois on April 17, 1974.

- Although substantially based upon the results of empirical inquiry conducted by the author and others, this paper is basically a position statement dealing with doctoral programs in science education as well as other areas of curriculum and instruction. -

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THE SCIENCE EDUCATION DOCTORATE: COMPETENCIES AND ROLES

The competitive job market in which new recipients of the doctorate in science education find themselves serves to emphasize what has been becoming increasingly apparent -- doctoral programs need to be modified to provide recipients of this degree with those specialized skills that are needed to accomplish the educational tasks faced in today's world. The inevitably increasing rate of change and specialization has brought us to the point where a science education doctorate without some specialization therein is inadequate preparation for most of the jobs for which graduates are competing. This is not to say that the doctorate in science education as a specialized degree is obsolete or that a strong background in science and a general background in such areas as educational psychology, sociological foundations, curriculum and research is not needed. In addition to his general preparation as a science educator, however, each recipient of a doctorate must have the preparation required to undertake at least one of several specialized functions for which science educators are responsible today. Information provided below in this paper is used as a basis for proposing that doctoral programs in science education should provide for in-depth training of students in one of three specialization areas in addition to this general science education preparation. Although every program need <u>not</u> provide for all three of these specializations, an attempt must be made to provide a quality preparation in those areas where it has the required institutional resources and faculty competencies. This situation obviously is not unique to science education; the discussion which follows probably is applicable to all those education doctoral programs commonly included in the area of curriculum and instruction.

RESEARCH ON EDUCATIONAL FUNCTIONS AND COMPETENCIES

Recently this author and others, under the auspices of the American Educational Research Association Task Force on Training Educational Research and Research-related personnel, conducted an analysis of the tasks and competencies of personnel engaged in exemplary research and research-related activities in education. This empirical study was initiated to begin filling a void in existing knowledge of the training of educational research and research-related personnel, namely the lack of information on the specific tasks performed by such personnel and the specific competencies required of them in performing these tasks. A full report of the research is available elsewhere;[1] only a brief condensation of those results relevant to this discussion are contained herein.

Since the study was focused upon personnel engaged in research, development, diffusion, and evaluation (RDDE) functions and these labels are used in the following discussion, a definition of these terms must be attempted here in spite of the fact that simple and satisfactory definitions are difficult to present.

Research describes phenomena or employs systematic procedures to test hypothesized relationships between variables with the goal of producing generalizable knowledge. This knowledge may or may not have direct and immediate practical applications. Although research includes historical and philosophical inquiry in addition to empirical inquiry, the term generally is focused upon empirical inquiry when used in the context of RDDE. While the term is used herein in this latter sense, no reflection upon the value or respectability of historical or philosophical inquiry is intended or implied.

Development (educational) is the endeavor of producing and testing materials (e.g., films, books, transparencies, laboratory equipment, or programs for

computer-assisted instruction) and processes (e.g., modular scheduling or individualized instruction) for use in schools. Research findings may be employed in the creating of the idea and the testing of the product is evaluation, but educational development clearly is an activity that makes use of competencies qualitatively different from those employed in research.

Diffusion is the process of initiating and stimulating the application of the results of educational research and development (knowledge, products and processes) in practice. It may include, among others, the dissemination of information, demonstrations of the use of the product, process, or knowledge, and procedure to facilitate the implementation of the product, process, or knowledge into school practice. Although not directly an inquiry activity, diffusion is necessary if research and development are to have an impact upon educational practices.

Evaluation is the activity of determining the value of an educational product, program, or process. As such it is directed toward aiding the decision-making process in education (e.g., deciding whether or not to adopt a new set of curriculum materials, modify a school scheduling procedure, replace a particular remedial program, or alter the process by which a school planning group is developing a new school program) rather than producing generalizable knowledge as is done in research. Although differing from research in its goals it is closely related to research in the technical skills required.

The data upon which the study of RDDE personnel was based were acquired through interviews with people identified as being engaged in exemplary educational research and research-related activities. The interviewees were selected from organizations such as regional educational laboratories, research and development centers, state departments of education and public school units which

were identified as being engaged in exemplary R,D,D, or E work or they were identified as individuals engaged in exemplary research work (the latter were almost entirely from universities). The structured interview employed was approximately of two hours duration and was designed to obtain information about the tasks performed by the interviewees and the competencies required in the performance of these tasks. Tasks (specific activities which are part of the conduct of research and research-related work, e.g., defining a research problem or preparing a script for a film) were viewed as collections of competencies (skills and knowledge necessary to complete a task, e.g., the ability to construct a good test item).

The data obtained were compiled and categorized (69 task categories and 226 competencies categories) and then analyzed by factor analytic procedures to find out what "clustering" of tasks occurred and what groups of competencies were associated with these task factors.

The 11 task factors which were identified and named are listed below.

1. Designing research studies and conducting and interpreting data analysis.
2. Developing instructional materials.
3. "First-level" administration of inquiry and inquiry-related projects and activities.
4. Conducting evaluations and constructing and using data collection instruments.
5. Diffusing information and products.
6. Developing and operating information storage and retrieval systems.
7. Evaluating inquiry and inquiry-related proposals and monitoring funded projects.
8. Searching, reading, and reviewing the literature.

9. Designing and maintaining computer systems and writing computer programs.
10. "Second-level" administration of inquiry and inquiry-related projects and activities.
11. Developing and scoring tests.

There are logical interrelationships between the factors identified above and the research, development, diffusion, and evaluation functions referred to earlier. For example, task factor 1 is clearly a central function of a researcher and to some extent, of course, is a function of evaluators as well. On the other hand, task factor 4 is a central thrust of evaluators although because of its data collection component it is a function of researchers to some extent also. Task factor 2 is obviously the central activity of developers today. In contrast to these rather specific functions, task factor 3 is common to all four of the areas - research, development, diffusion, and evaluation.

In the original report of this research there is a more extensive discussion of the ways in which these task factors are related to the RDDE rubric along with a presentation of the competencies employed in each of these functions. Such a discussion of competencies will be presented herein, however, under somewhat different categories in the section below.

PROPOSED DIFFERENTIATION OF FUNCTIONS

A new framework of functions is proposed here which is more consistent with the categories of activities in which science educators and other persons in curriculum and instruction find that they have responsibilities. This framework includes three areas: (1) research and evaluation, (2) development, and (3) instructional leadership (teacher education and implementation of curricular

change). It should be emphasized, moreover, that the three major functions proposed here are identifiable in terms of both the function itself as engaged in by science educators and the clusters of competencies required within each function.

Research and evaluation. These two functions are grouped together here because of their commonality in terms of the basic competencies required in each. There is a great deal of overlap in the competencies employed, e.g., ability to employ statistical analyses procedures, ability to design data collection instruments, and knowledge of measurement theory. At the same time, there is no intent here of attempting to blur important distinctions between these two activities. In fact, every effort should be made to make an understanding of the distinction between research and evaluation much more widespread within the science education community. They clearly are activities of quite different natures. The basic goal of research is the acquisition of knowledge which leads to statements of generalizable applicability while the evaluator seeks information which is useful for decision-making. But in terms of doctoral programs in science education, it probably would be well to treat them as a single specialization in view of the great deal of commonality in basic competencies required. Even so, a doctoral student may choose to develop his expertise more fully in one of the two facets of this combined area depending upon his interests and the competencies of the faculty with which he is working.

Development. The last decade has seen the emergence of educational development as an area of considerable activity requiring unique sets of skills. The variety and sophistication of the competencies required in this area is extensive (such as the ability to use various media, the ability to develop materials in such a format, the ability to sequence learning activities, knowledge of the educational setting in which materials will be used, and the ability

to revise materials on the basis of field test feed-back). Thus, development has become a unique area both in terms of the competencies required and the demands for people with these competencies. Basically, the goal of personnel engaged in development activities is the production of useful materials or products for educational situations.

Instructional Leadership. Activities within this category are designed to bring about changes in the behavior of people and modifications of social systems within which they interact. This is in contrast to research and evaluation in which the goal is the production of knowledge or information and development where the goal is the production of educational materials or approaches. This category includes persons engaged in such activities as pre-service or in-service teacher education and personnel who work with teachers and/or administrators to alter the curriculum of students. This is the area in which science educators as a whole today probably have the greatest amount of experience and training and most frequently are employed.

COMPETENCIES REQUIRED BY FUNCTION

Before pursuing the main thesis of this paper, i.e. that doctoral programs should contain specializations in accordance with the functions identified above, attention must be given to the competencies required to engage in these three functions in an exemplary fashion. The research to which reference was made earlier provided rather extensive information concerning the competencies required of persons engaged in research and evaluation or engaged in development. Unfortunately, the same delineation of competencies required of people in the instructional leadership category has not been provided by empirical

study. In that area we must depend more upon informed opinion and experience.

Although exhaustive descriptions of the competencies required for each function can not be given here, examples can be. In the list provided below are examples of competencies commonly employed by personnel engaged in exemplary research and evaluation activities. The list includes many of the more common competencies found in the study described earlier but is not intended to be inclusive.

Ability to design card layouts to allow data analysis within computer constraints and ability to use standardized computer programs (e.g., BMD series).

Knowledge of how computers might be used to analyze data.

Knowledge of t-tests and critical ratios.

Knowledge of alternative methods of presenting statistical data (e.g., charts, graphs, or tables).

Ability to use computer coding.

Knowledge of ANOVA or ANCOVA designs and techniques.

Ability to read and interpret computer output.

Ability to keypunch.

Knowledge of questionnaire construction techniques and appropriate uses for questionnaires.

Knowledge of factor analysis techniques.

Ability to allocate time and money wisely in arranging computer work.

Ability to describe, explain, or elaborate in writing.

Ability to choose (or design) appropriate statistical techniques for data analysis.

Knowledge of statistical variance and standard deviation.

Knowledge of theoretical assumptions underlying various statistical techniques.

Knowledge of statistical regression techniques.

Ability to design studies to control extraneous variables.

Ability to use library research techniques.

Ability to incorporate systematic evaluation procedures into plans for developing educational programs.

Ability to work with public school, university or state department or education personnel.

Ability to identify educational needs that should be addressed by educational systems.

Ability to develop techniques for providing evaluative feedback to program or project personnel in time to allow needed modifications to be made during the operation of the program.

Ability to help others identify and state their objectives.

Ability to discuss the advantages of establishing evaluation systems in educational institutions.

Ability to work effectively with decision makers.

Knowledge of personnel and the organizational structures of public school systems and universities.

Ability to put quantitative or numerical information into verbal or narrative form.

Ability to determine the evaluative questions which must be asked in evaluation and the information which must be gathered to answer these questions.

The competencies listed below are examples of the competencies employed by many of the personnel engaged in exemplary educational development. Again, the list is intended to provide examples of those competencies which empirical inquiry has shown are actually employed and it is not intended to be inclusive. In addition to those competencies listed below, developers employ many of the competencies required of evaluators (the last ten of the above list for research and evaluation).

Knowledge of current theories of learning, especially as they relate to theories of instruction.

Knowledge of developmental psychology or the field of psychology in general

Knowledge of the role of the teacher including abilities which normally can be expected of teachers.

Knowledge of instructional approaches that might be incorporated in teaching or designing instructional materials.

Ability to establish rapport with children and obtain their cooperation in testing situations.

Knowledge of theory and techniques for assessing student achievement.

Knowledge of printing constraints and specifications.

Knowledge of steps involved in the mass production of curriculum materials (e.g., reproduction and packaging processes).

Ability to determine financial resources necessary to conduct a program or project and use accounting procedures to operate within a program or project budget.

Ability to supervise personnel.

Ability to outline specific procedures for working through a problem.

Ability to write in a style and at a level appropriate to a specified audience.

Neither the study described earlier nor other empirical research available has much to say about the specific competencies required of people working in teacher education and the implementation of curricular change in school systems. The above research produced some information about diffusion as defined previously but most of the diffusion activity was limited to the dissemination of information with few of the people who were interviewed being engaged in other aspects of dissemination such as trial teaching of materials or working with school personnel to put the materials into practice. Experience with teacher

education and the implementation of curricular change, however, would seem to indicate that personnel being trained in this area should acquire, for example, considerable knowledge of and competence in training teachers to use a variety of educational materials (e.g., films, science laboratory equipment, printed materials, and materials collected from the out-of-doors) in a variety of educational settings (large lecture groups, small discussion groups, independent studies, encounter groups, and the out-of-doors). Extensive knowledge of school systems and the social interaction therein, also are among the competencies required of the person who is to bring about meaningful educational change in the place where students and teachers spend their time. The extensive knowledge of and abilities in employing science content, human learning, social interactions, and educational practices required is obvious. The ability to analyze and evaluate the great variety of educational practices with both formal systematic approaches (such as with classroom observation systems) as well as with less formal means also is critical. It is informative to note that several of the competencies one would expect of personnel in this area are employed by developers as well (see the above list of competencies for developers).

It is proposed that doctoral programs in science education should make provisions for preparing students in depth in one of these three areas in addition to the more general science education background to which reference was made previously. This does <u>not</u> mean that every doctoral program in science education should make provision for specialization in all three of these areas, nor that a given student may not study in depth in more than one area. Every attempt should be made to develop programs, however, that do a quality job in those areas where the necessary faculty competencies and institutional resources are available; the students who wish to work in other areas should be advised to go to another institution.

RESEARCH ON RESEARCH TRAINING

Before proceeding to a discussion of specific recommendation for doctoral programs in science education reference must be made to the existing body of research in the area; it is informative. Unfortunately, most of the research deals with training personnel for educational research with little empirical inquiry-based information on the training of evaluators, developers, or teacher educators. From the findings and conclusions available on research training, however, it is possible to make some extrapolations to the other areas.

In the study referred to earlier[1] a thorough review of the existing literature on the training of educational research and research-related personnel was conducted. An extensive search was made for all the literature in this area. The literature then was judged for methodological adequacy and the findings of those judged to be adequate were synthesized. The studies cited below are selected for their apparent relevance to science education and are not intended to be inclusive of all the studies judged to be methodologically adequate. This relevant extant research is divided into two categories, (a) personal characteristics of the research trainee and (b) variables related to research training programs.

Trainee Characteristics

All of several studies dealing with the age of recipients of the doctorate in education consistently give the same result -- those persons who obtain their doctorate at a younger age tend to be more productive of research. On the other hand, the research also shows that education doctorates tend to be older at the time of receipt of the degree than do recipients of the doctorate in most other fields. This discrepency in age is a significant matter.

The research also indicates a substantial relationship between research productivity and the amount of time spent in continuous full-time residence as a

doctoral student. This relationship has been found in the field of psychology as well. Along with the fact that the more productive researchers spend more time in continuous full-time residence and complete the degree at a younger age, it is found that the pursuit of a doctorate in education is largely a part-time endeavor. Again, the results of this research have significant implications for the training of researchers in science education.

A third area that has implications for the recruitment of personnel for entry in training for research in science education is the relationship between professional experience and research productivity. A negative relationship has been found between research production and teaching experience. A negative relationship also has been found between research quality and a variable identified as "practice oriented socialization" (teaching experience, possession of an Ed.D. rather than a Ph.D., or professional education courses). The most productive researchers typically have not been as involved in the practitioner's side of the profession prior to becoming researchers.

Program Variables

The research on the training of educational researchers also has dealt with various characteristics of training programs and the production of researchers (production in the sense of the number of researchers trained, not the research productivity of the researchers as discussed in the previous section). The research shows, for example, that those schools which are most selective in their admission procedures are most productive of researchers in education. It has been concluded that the greater an institution's selectivity the greater is its output of researchers.

Researchers have also concluded that something which might be called "research climate" is related to an institution's production of researchers. Among the various measures of research climate identified through such research are the

following: the quality of the research produced at an institution, the scope of this research, the importance attributed to research by deans, the proportion of the faculty doing research, the level of graduate apprenticeship on projects, and the number of joint arrangements with other departments for conducting research. Other institutional characteristics are early emersion in ongoing research projects, a close relationship with productive research professors and an emphasis upon program flexibility and independent study.

One of the more important findings of the research in this area is that research apprenticeship, such as holding a research assistantship, is associated with research productivity. Furthermore, the nature of this research assistantship experience has been found to be highly important. A critical factor is whether or not the person was actually engaged in research work rather than being involved in non-research activities. Moreover, among those persons who held a genuine research assistantship further distinctions could be made between productive and non-productive researchers according to the nature of research activity in which they were engaged. Productive researchers more often had experience with the conceptual stages of the research, the use of statistical analyses and in using the computer. The research clearly shows that appropriate use of the research assistantship is an important aspect of research training. This is particularly important, in view of the fact that the research also provides some indications that the dissertation does not serve to provide the research training that it might.

EXTRAPOLATIONS TO DEVELOPMENT AND INSTRUCTIONAL LEADERSHIP

As noted previously, the research cited above is devoted almost exclusively to the study of the training of educational researchers and specifically does not include research on the training of developers or personnel for teacher education and other instructional leadership roles. Unfortunately, research in these latter

two areas appears to be essentially non-existent. Even though it is hazardous, probably the best means of acquiring information at the present time is to attempt to make extrapolations from the research on the training of researchers to the areas of development and instructional leadership. The following statements are made for that reason with full recognition of the hazards involved.

Research referred to above concerned three characteristics of persons involved in educational research: (a) age, (b) the extent to which they attended graduate school on a full-time basis, and (c) the extent to which their socialization was practice-oriented or research-oriented. Of the three it probably is most difficult to make extrapolations from the findings on the age of research trainees to development and instructional leadership trainees. It seems plausible that educational practitioners who enter a research training program must make a bigger shift in the nature of their activities than practitioners who enter a training program in development or instructional leadership. Not only does entry into research work require a change in activities, it requires a strong shift in values for personnel with practice-oriented socialization. If this assumption is correct, and if it is more difficult for an older person to make such shifts, it may be that age is a more important factor in selection of personnel for research training programs than for programs in instructional leadership.

It seems fairly safe to extrapolate from research to development and instructional leadership in the case of the degree of full-time residence as a doctoral student. In a situation where adequate training is highly dependent upon apprenticeship types of experiences, it seems plausible that the extent of full-time emersion in the program would be an important factor.

An inference that could be drawn from the research on practice-oriented socialization versus research-oriented socialization is that people should be selected for a given training program who have socialization that is consistent

with that of the program. Practice-oriented socialization, for example, may be found to be positively related to success in the field of teacher education. Empirical study of this matter is needed.

The research on characteristics of training programs also may provide some important insights. It would seem safe to infer, for example, that selectivity would be important for training productive developers and instructional leaders, assuming, of course, that the selection criteria employed were related to the performance expected of persons being trained for work in development or teacher education. In a like manner, knowledge that a "research climate" is correlated with the production of researchers could be used as a basis for inferring that a "development climate" or "instructional leadership climate" would be positively related to the production of personnel in these fields. Just as faculty members who actually are doing research contribute to a research climate, so it would be expected that involvement in development or instructional leadership would be an important part of creating a climate which is conductive to the training of personnel for these fields.

The fact that appropriate apprenticeship experiences seem to be so strongly related to the production of researchers cannot be overlooked in creating graduate programs for training developers and teacher educators and implementors of curricular change. Probably no facet of the training program is more important than this; it is critical. Again, as in the case of training for research, it would seem that the dissertation cannot be depended upon for this apprenticeship experience. In fact, given the current nature of dissertation work, it seems reasonable to assume that the dissertation is even less likely to serve this function in the case of development and instructional leadership than in research.

RECOMMENDATIONS FOR SCIENCE EDUCATION

As indicated previously, the main recommendation of this paper is that the specific focus or foci of doctoral programs in science education be identified and then the program built up in these areas. The three potential areas of emphasis identified were (a) research and evaluation, (b) development, and (c) instructional leadership. Specialization of this type is demanded in today's job market, and it clearly has a basis in the job competencies required of educational personnel. This type of specialization, of course, does not eliminate the need for a general background in science education or some course work and/or experience in the two areas in which the person is not concentrating. The person whose focus is instructional leadership, for example, still will need to take course work in statistics, research design, and measurement in order to adequately deal with the published research in teacher education. Likewise, it does not eliminate the possibility of a dual concentration such as in science teacher education and research. This, in fact, is an example of a combination that hopefully will be in demand since there is much activity on the teacher education front today and research and evaluation are needed to provide the empirical basis for advance in this area. In addition to the three areas identified above, there may be other specializations or particular combinations of areas identified earlier in which institutions may wish to concentrate. For example,a program might be focused upon the history and philosophy of science education. The key points, however, are that (a) the job market today demands specialization and (b) most institutions do not have the resources and personnel for operating a quality program in all three areas.

Obviously what is being recommended here is not the formation of new doctoral programs in science education but a refining of existing ones. The personnel in charge of doctoral programs should evaluate carefully their current strengths and potential areas for growth to adequately pinpoint those areas in which they can

provide adequate training for doctoral students. The extent of faculty involvement in the areas of research and evaluation, development, and educational leadership, as well as the opportunities for increased involvement and/or improved competency must be considered. Another consideration is the extent to which there is potential for involvement of doctoral students in the work of other university departments and nearby agencies outside of the university where they can gain suitable apprenticeship experiences in one of the three areas.

The selection of students is another area which needs to be given some attention according to the conclusions of research. Today's job market would indicate that the need for careful selection of students is even greater than in the past and the research indicates that selection criteria can be applied in a way that will increase the probability of getting the better people into the field of science education. In the case of research, at least, age is clearly a factor which should be considered in the selection of graduate students for a doctoral program. The young age is fairly preferable although the practice-oriented nature of science education is such that some science teaching experience should be required of everyone. An inference that might be made on the basis of the research referred to previously is that students should be selected, to some extent, on the basis of the socialization that they have had. The practice-oriented socialization referred to above may result in an individual who is less likely to be interested in research than he is in teacher education. This basis for selection probably should be approached with great caution, however, in that science education specifically required people with a practice-oriented base of experience. The author also is cautious about this recommendation because many science education students who ultimately do become interested in research apparently were not aware of this interest prior to their exposure to research in a doctoral program. The research also indicates quite clearly that selection of students on the basis of

ability is a benefit. The crucial question is what constitutes ability in each of the three areas of research and evaluation, development, and teacher education. Further research is obviously needed here to determine specifically what entry abilities are most important in each of these three areas. A final consideration in the selection of students is that self-selection operates to a large extent and is of fundamental importance. This means that adequate information must be available for students about the specific nature of the doctoral program which they are considering as well as information and assistance that will help them evaluate their own interests and goals.

The research has established quite conclusively that the type of apprenticeship experience which a doctoral student gains is a key facet (possibly even the most important facet) of a program. There probably is no aspect of existing doctoral programs which has more potential for improvement than this one. Faculty involvement in the appropriate area, such as educational development, is of key importance if this apprenticeship is to exist. The person who expects to train researchers must be involved in research himself and provide the opportunity for doctoral students to become involved in this work at a conceptual level and not just at the clerical level. As a minimum, it would seem that this involvement should be at least extensive enough that the doctoral student and the faculty member would co-author at least one research publication prior to the student's work on a dissertation. Similarly, the student who expects to concentrate in educational leadership should have the opportunity of working with a faculty member in new approaches to teacher education such as the development of teacher education modules and gain some experiences in working with schools in a leadership role in implementation of curricular change. Again, the need for specialization within programs on the part of faculty probably is apparent. One faculty member could not expect to seek outside funding and operate programs in all three areas and be adequately involved.

A second need, if adequate apprenticeship experiences are to be provided, is to work out acceptable cooperative arrangements with other agencies both on and off campus. Cooperative arrangements need to be built first of all with many groups within the given school of education. For example, it is very unlikely that a student whose area of concentration is research and evaluation could receive adequate preparation without intensive involvement with the faculty members of the area of research and evaluation. The involvement should be intensive and include at least a small amount of apprenticeship type experience with such persons in addition to the conventional course work in the area. The person interested in teacher education needs to work with personnel such as a faculty group developing competency-based teacher education modules or a group involved in development of encounter group type experiences for teacher education. Another example of on-campus groups with whom cooperative arrangements would be advantageous is a bureau of audiovisual instruction or some other group involved in the production of educational media. Apprenticeship experience with such a group would be invaluable for the student in development.

Similar kinds of cooperative arrangements can be made with off-campus groups. For example, if there is a curriculum development project within a reasonable distance, arrangements could be made for development students to gain excellent apprenticeship experience with them. Cooperative arrangements often can be made with public schools, particularly with a research or evaluation unit where some work related to science education is being done. The instructional leadership student would find experience in working with the science consultant of a state department or school district on an internship basis to be very beneficial.

Attention also should be given to the type of seminars in which students are involved; seminars in science education are not sufficient by themselves. The development students, for example, should have the opportunity of being in a seminar

with students from fields other than science education where the focus is development. Seminars on research, evaluation, development, teacher education, etc., including students from many different fields should be an important part of the doctoral program. The need for apprenticeship experiences and the need to integrate theory and practice would seem to require that these seminars, as well as seminars in general, be tied in some way to experience and actual work in the relevant area.

Most of the characteristics being advocated above should contribute to something else which the research has indicated is desirable, namely an appropriate "climate," such as a research climate. Possibly what constitutes a desired climate in any one of the three areas is really expressed in operational terms by the recommendations made above. In addition, it would seem that the appropriate climate for the student would be enhanced by full-time residence for as long a period of time as is possible. The research provides us with a basis for at least strongly recommending to the student that this be the case. Research in this field also would indicate that we cannot depend upon the dissertation as an adequate apprenticeship even in the area of research. Apprenticeship experiences and emersion in the field must be characterics of the program. For too long too many people in education have been willing to think of a doctoral program in terms which are similar to those for bachelors and masters programs, namely the taking of a sequence of courses. Within the kind of climate advocated above, the dissertation may be less of a stumbling block to some students with a resultant fewer number of people of the "all-but-dissertation" type.

A final point is that student advisement is critical to any program. Students should know ahead of time the type of program they are entering as well as the other options that are available, not only at the particular institution which they are considering attending, but at other institutions as well. Student recruitment is

important for the development of strong programs but at the same time there is a fundamental responsibility to the student to provide him with as complete information as possible in order that he may make the best decision for himself. Student advising and concern for students in other ways must continue throughout the program. The possibility for them to make choices and influence their own program obviously must receive high priority.

FOOTNOTES

[1]Worthen, B.R., R.D. Anderson, and M.L. Byers, A Study of Selected Factors Related to the Training of Researchers, Developers, Diffusers, and Evaluators in Education. Washington, D.C.: American Educational Research Association, 1971. (Final report of USOE grant OEG-0-71-0617 (520) - 482 pp.)